Emerging Technologies and Active Pedagogies in Initial Teacher Education: Preliminary Findings from a Systematic Review

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***Abstract* — Initial teacher education is under growing pressure to prepare future teachers for technology-rich classrooms and for pedagogical approaches that promote active student participation. This study presents preliminary findings from a systematic review examining how educational research addresses digital, emerging, and generative technologies in relation to the development of active pedagogies in initial teacher education. The review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. Peer-reviewed articles published in English or Spanish between 2015 and June 2025 were retrieved from Scopus, Web of Science, and Dialnet using three search strings related to new technologies, generative artificial intelligence, and active pedagogies in initial teacher education. Eligible studies focused on pre-service teachers and teacher educators in European and Latin American contexts. After full screening, 66 articles were included. Preliminary findings indicate that literature pays considerable attention to technology integration in school settings, whereas fewer studies examine how initial teacher education programs prepare pre-service teachers to implement innovative pedagogies supported by emerging technologies. These findings point to a persistent misalignment between teacher education, emerging technologies, and active pedagogies, as technology is often approached as a technical resource rather than as a driver of pedagogical transformation. The study offers an updated overview of research trends and identifies a persistent gap in the preparation of future teachers for innovative classroom practice.**

***Keywords* — initial teacher education, pre-service teachers, emerging technologies, active pedagogies, teacher preparation, systematic literature review, generative artificial intelligence**

I. INTRODUCTION

Traditional teaching has become a problem in the current educational ecosystems since the span of students' attention has been reduced and learners feel either that schools do not cater for their interests or that the information schools offer to them can be easily found on the Internet. In this context, it is necessary for teachers to redesign education not so much in terms of content but in terms of the experiences students have in their classrooms. Active methodologies seem to be the key to meaningful teaching environments. On thinking about them, we can go from project-based learning to flipped classroom including cooperative learning, problem-based learning, task-based learning, design thinking for education, to mention a few of them and in the digital age we are living, these pedagogies have been enriched by ICT, emerging technologies and artificial intelligence including generative artificial intelligence

When students are taught through active teaching methodologies, they become the centre of the learning process, and they manipulate content in a way that it becomes meaningful to them. On the other hand, the content they are expected to learn is more connected to the real world. Therefore, local and global issues become part of their daily learning.

II. LITERATURE REVIEW

Active methodologies in initial teacher education

In active methodologies, students not only learn content but also develop 21st-century skills such as creativity, collaboration, communication, citizenship, and critical thinking. Fullan and Langworthy [1] added the idea of character development and referred to them as the 6C.
Powerful teaching, defined by Maggio [2] as a teaching that leaves a footprint in students' lives by dealing with present issues which stay in their memories, is also connected with active methodologies that produce deep learning [1]. A comparison between teacher-centred approaches and student-centred approaches [3, 4] goes hand in hand with technology inclusion, but between those two extreme groups, many future teachers have middle positions because they accept the views of the student-centred approaches [3] but they are not totally against those in the other group.
Table 1 gives an overview of the different approaches to teaching grouped as active pedagogies that put the student at the core of the learning experience.

Table 1: Active methodologies and their main features

Active methodologies	Main features
Project-based learning	Approach based on real world problems in which students working cooperatively create a final product.
Problem-based learning	Similar to project–based learning but there is no need for a final product.
Inquiry-based learning	Approach in which there is a big question whose answer students try to find by means of research during the learning experience.

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Collaborative learning	Learning which is carried out by means of teamwork.
Gamification	Introduction of game elements such as points, tournaments, missions, or challenges to revise contents from different subjects.
Game-based learning	Introduction of games in the classroom for the presentation or revision of curricular contents.
Flipped classroom	Rotation of classroom organization in which the input in relation to new topics is given at home generally through an online space created for that purpose and activities to put that content into practice is done in class.
Microteaching	A widely used method for teacher training in which trainee teachers practise teaching a topic for a short period of time no longer than fifteen minutes.
Experiential learning	Mainly related to learning by doing. It has to do with direct experiences, and hands-on activities.
Service learning	Approach in which students learn while they are solving real problems in their own communities by means of a project.
Case-based learning	Teaching approach based on case studies intended to develop students' critical thinking and problem-solving skills.
Design thinking for education	The principles of design thinking enter the classroom with a five-step methodology (empathize, define, ideate, prototype and test) that help students to develop problem-solving skills.
Historical method	Model historians use to interpret evidence
STEM, STEAM, STEAM + H	Approach that focuses on the integration of science, technology, engineering and maths to the teaching of different disciplines. It can be extended to STEAM when arts is included and to STEAM+H to refer to humanities.

New technologies in initial teacher education

A key topic in our systematic review was the integration of technology in initial teacher education, mainly to accompany the focus of this paper, that is to say, to enhance active methodologies in teacher training programs. Rivas presented new technologies as dynamic educational infrastructures which expand the right to education, create new learning opportunities, and help educators rethink teaching practices as long as they are pedagogically oriented [5] whereas Burbules, Fan and Repp defined them as socio-technical environments that can bring opportunities and risks to education depending on how they are used in the teaching process so educators should look at them with critical lenses when integrating them [6].

Maggio defined two kinds of technology inclusion in the classroom: effective inclusions and genuine inclusions [2]. The former are the result of the pressure teachers and future teachers receive to include them from supervisors, school authorities or educational policies while the latter are those in which technology integration is the result of educators' perceiving information and communication technologies (ICT) and emerging technologies potential to improve learning in the discipline they teach. Interactive tools, online videos, videogames, learning management systems (LMS), automatic response systems (ARS) and augmented reality (AR) are the most frequently included tools in educational practice at present.

III. Materials and Methods

In our systematic literature review on ICT, emerging technologies, artificial intelligence and active methodologies in initial teacher education, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol was followed, with the intention of identifying, selecting, and analyzing studies located in the main academic databases, namely, Scopus, Web of Science, and Dialnet. The inclusion criteria were peer-reviewed studies published in English or Spanish between 2015 and 2025 as well as research examining prospective teachers and their trainers in European and Latin American contexts. "New technologies and initial teacher training," "artificial intelligence and initial teacher training," and "active methodologies and initial teacher training" were the search strings used. For inclusion in our study, it was also required the population sample to be composed of prospective teachers enrolled in universities or teacher training institutions who were pursuing education studies to teach at primary level and prospective teachers completing master's programs in specific disciplines to qualify for teaching at secondary level. Studies that included prospective teachers across mixed educational levels were also included. Conceptual, theoretical and conference papers were excluded.

All references were managed using Zotero software, where separate folders were created to organize the articles retrieved from each database according to the corresponding search string. The systematic search yielded 327 articles from Scopus, 263 from Web of Science, and 28 from Dialnet, resulting in a total of 618 records. Additional studies were incorporated manually based on their relevance to the research objectives, resulting in a final number of 685 records.

Following the retrieval of studies from the selected databases, records were imported into *Rayyan* for systematic management and screening. A total of 127 duplicate records were identified and removed. From the remaining 558 records, 390 were excluded during the screening phase in which records were examined by title and abstract to determine compliance with the established inclusion criteria. That process resulted in 168 studies retained for full-text retrieval and assessment. For reasons consistent with the predefined exclusion criteria, 102 studies were excluded in that last stage. Therefore, 66 articles were finally included in our systematic literature review.

Once the demographic information from the corpus was extracted and a database was created, a thematic analysis was conducted using an inductive approach. Then, we followed what Braun and Clarke [7] called an immersive reading of the full texts in search of familiarization with the data. When we were familiar enough with the data, we codified the articles so as to establish the common themes. Then, we went through an iterative process with several readings to redefine the themes we had first established in our first analysis. From this thematic analysis, one of the themes elicited was instructional design and, within this topic, we decided to focus on active methodologies supported by ICT and emerging technologies for the purpose of this work.

IV. Result and Discussion

Across the three databases we examined, using new technologies, artificial intelligence, and active pedagogies in initial teacher education as search strings, there was a marked predominance of studies addressing the integration of ICT in initial teacher education compared with the relatively limited number of works focusing on artificial intelligence or active methodologies in initial teacher training as shown in Fig.1.

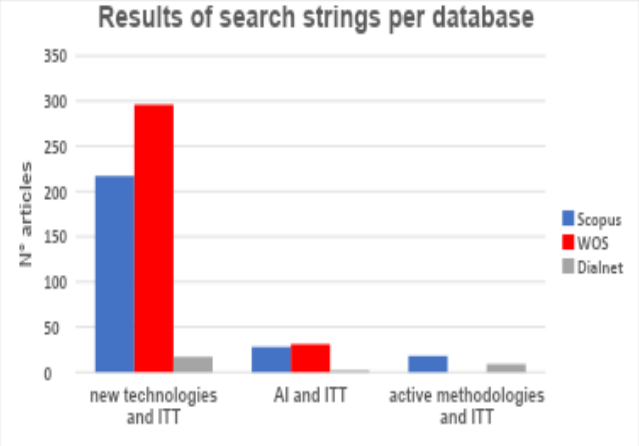


Fig. 1: Results per search string

From the 66 articles retrieved to be included in this systematic review, only 16 were related to active methodologies which is the focus of this paper. When we refer to active pedagogies, it is worth mentioning that not all of them are new in educational settings. For instance, project-based learning dates back to 1918 when William Kilpatrick introduced it for the first time. However, the introduction of ICT and emerging technologies in the educational field has shed new light on them [8]. The small number of articles retrieved dealing with project-based learning or other active methodologies in initial teacher education may indicate preservice teachers' lack of readiness to include them in their future classrooms.

Simulations, in our systematic review, were presented by Merchán Gavilánez et al. as active methodologies that allowed preservice teachers to focus their attention on one objective at a time and allowed them to take decisions out of simulated classroom practices as well as microteaching did [9]. Microteaching supported by new technologies, which is a typical approach used in teacher education to in some way simulate real classroom teaching, led to reflexive practice in initial teacher training generating less anxiety and more motivation in preservice teachers [10] by providing preservice teachers with moments of dialogic interaction and reflection which helped them develop better pedagogical and technical competences. According to Rodrigues [4], these active pedagogies fostered the meaningful development of skills such as communication, problem-solving and critical thinking in initial teacher education.

Another active methodology that was part of some of the articles retrieved was gamification which involves including the mechanics of games in classroom activities to increase students' autonomy and motivation and also to accelerate learning [11]. Out of the papers which dealt with this approach, two of them studied gamification in preservice history teachers. In the authors' views, gamification in the classroom in the context of history teaching made it possible for preservice teachers to move from data memorization to the implementation of skills which are necessary for historical research [12], and this is in correlation to Maggio's claim [2], when she states that it is important to work in teaching contexts in the same way as experts in a particular field do so. Preservice teachers who most valued the introduction of videogames in history classrooms were those who were more aligned with new pedagogies [13] and this can be justified by the fact that they dare to experience new approaches to teaching. Following that line of thought, videogames and comics proved to create a gap between more traditional and more innovative preservice history teachers in these studies. It was also found that in many cases, ICT and emerging technologies were incorporated to add fun through gamification but not to foster critical historical thinking and that was something that Piedra Moreno, [14], studying maths preservice teachers, warned against by claiming that gamification should not be incorporated only to avoid classroom boredom. We agree with this author that certain games could reproduce traditional teaching models based on trial and error and that students may try to solve games quickly. As it happened in the case described by this author, students tried to solve maths operations to score points without really thinking about the mental processes they were using to solve the maths problems they had been given. In their research, Ariza Carrasco et al [13]. found that those preservice teachers with a "gamer" profile valued the use of augmented reality with mental maps more positively. They noticed that the interrelation of gaming with augmented reality and collaborative

techniques had improved preservice teachers' learning and social interactions in the initial teacher education programs studied. In conclusion, we suggest that when preservice teachers use gamification to enrich their classroom practice, teacher educators need to guide them to consider the reflective processes that the games introduced should trigger off to enrich learning.

When connecting active methodologies and technology integration, working collaboratively with colleagues has shown anxiety reduction in using technology in teacher educators as well as in preservice teachers [15,16] so we assume that in both cases, collaborative learning fostered experimentation with ICT and emerging technologies providing users with improved security. Our belief is reinforced by Tondeur et al. [17] who claimed that preservice teachers with a positive attitude to technology integration prioritized cooperation and teamwork at the moment of integrating ICT and emerging technologies. Collaborative learning with technology integration proved to be one of the active methodologies given the highest score as to its effectiveness [4] followed by formative evaluation and problem-based learning. This may account for the fact that collaborative learning was the active methodology most retrieved in the corpus of this review. In some of the articles, collaborative learning was implemented in teacher education institutions using specific tools. For instance, the socialization of learning through video annotations gave room to meaningful exchanges between preservice teachers and teacher educators in the study carried out by Martínez Romera and Cebrián-Robles [18], whereas the jigsaw technique along with virtual mental maps fostered personal security in preservice teachers in Ariza Carrasco's study [13]. On the whole, no matter the tools involved, researchers in agreement with our thoughts, acknowledged the benefits of collaborative learning for initial teacher education, and they highlighted how different technologies can facilitate collaboration both, in face to face and in hybrid classrooms.

The acronym PBL in the literature reviewed stands for two active pedagogies: project-based learning and problem-based learning. Whereas both consider real world problems, the former generally calls for both collaborative learning and the creation of a final product while the latter can be put into practice individually and no final product is required. Project-based learning as well as problem-based learning foster the development of critical thinking and problem- solving skills as much as other active pedagogies already described. Active teacher training was achieved in Rodrigues' study [4] through technology- supported project-based learning (PBL) involving a continuous flow of active work that went from planning digital tasks to the creation of digital final products and individual reflections in the evaluation stage of a project. Tools such as LMS, *Zoom*, *Kahoot* and *Padle*t were used to create a virtuous digital ecosystem inside the PBL framework.

A great connection between theory and practice during the practicum of primary education was reported using problem-based learning [19]. The preservice teachers involved in this study identified real challenges in the classroom and proposed solutions based on reflection. It developed an increased feeling of self-efficacy, more recognition of diversity, communication improvement in technological ecosystems as well as better conflict resolutions. We consider that both active pedagogies should become part of the preservice teachers' curriculum for the benefits they may bring to their professional growth and to their future students' development 21st century skills.

Two of the newest active pedagogies we found in our systematic review were flipped classroom and STEM. In the case of flipped classrooms, they can be regarded as an alternative to traditional education. Whereas theory is in the foundations of traditional education and traditional teaching is associated with memorization, conceptual and repetitive learning [20], practice is in the core of flipped classrooms [21]. By using flipped classrooms, preservice teachers used videos at home to learn concepts in a flexible and autonomous way and face-to-face lesson time was used to solve tasks and problems with teacher educators' guidance. Once again, some new technologies had a key role for this active methodology in the papers in this review. For instance, *Kahoot or Mentimeter* were used by teacher educators to give immediate feedback in a motivating way and preservice teachers were able to perceive their own improvement. They also recognized that this methodology respected individual learning rhythms and needs, and they also agreed that automatic response systems (ARS) such as *Kahoot* used as part of this methodology helped them fix knowledge. In this sense, we may say that flipped learning potentially developed preservice teachers' high-order thinking skills by allowing them to receive constant feedback from teacher educators through collaborative dynamics mediated by ICT and emerging technologies [21]. The use of the flipped classroom with future teachers of bilingual education was considered a useful methodology to improve prospective teachers' 21st century skills, therefore Molina- Torres [21] found flipped classroom to be a methodology of vital importance for initial teacher education. In the same line, Serrano and Casanova [20] reported its benefits for preservice music teachers since they regarded flipped classrooms as time maximisers for practical activities and they also stated that preservice teachers' creativity and collaboration skills may have been developed by this approach. Therefore, we consider that preservice teachers should be prepared to include flipped classrooms in their future lessons for the benefits presented in the different disciplines in which this pedagogy was used in the research we examined,

STEM, which stands for science, technology, engineering and maths, was only represented by one study in our review carried out by Trapero-González et al. [22]. When a STEM approach is followed, at least two or more of these areas are often integrated. These authors found that male preservice teachers showed better performance in STEM knowledge depicting a persistent gender gap in the areas that make up STEM. This gap is also given by a greater sense of self-efficacy exhibited by male future teachers. When there is a member of the family linked to the STEM area, performance was proved by the authors to be better. Strong pedagogical knowledge was found by the authors to correlate with better technical and technological teaching, and it is worth noting that a good domain of 21st century skills such as critical thinking and collaboration contribute to better application of a STEM approach to teaching. We understand that more

studies are required to analyse examples of good STEM practices in teacher education and that the gender gap found by the authors working with this methodology should be bridged

Fig. 2 shows the level of representation of each active methodology that appeared in our corpus

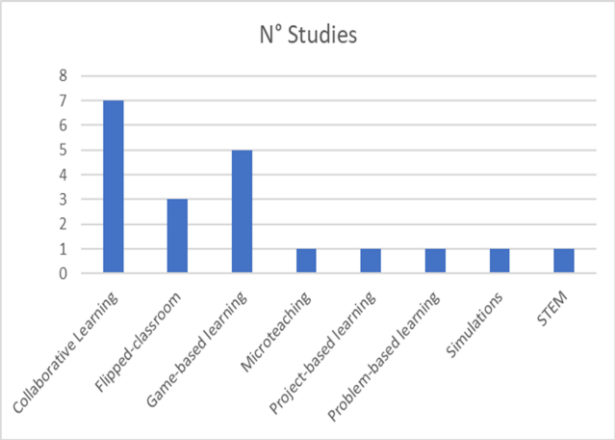


Fig. 2: ICT- supported active methodologies in our corpus

In relation to the emerging technologies used in the articles retrieved in this systematic review, students' motivation tended to be one of the reasons for which future teachers wanted to include ICT and technologies in their lessons [3, 14, 23-25]. Preservice history, English and maths teachers associated ICT with motivation and fun, but when that was the only reason for technology inclusion, their value became anecdotical as Gómez Carrasco et al. [3] concluded after their research with future history teachers. In their study, videos and virtual field trips of museums were better valued than videogames or other apps. However, Diaz et al. [24], and Cerda, Narvaez and Mercado [26] expressed the importance of creating a digital ecosystem instead of using isolated tools and showed the positive results of having integrated a learning management system (LMS) like Google Classroom with *Kahoot* and videoconferencing applications. Whereas emerging technologies were found to improve instructional design, desk software was considered an ally in classroom planning and hardware knowledge is the least predictor of TPACK integration [27]. Higher digital competence resulted in better informed choices of tools that enriched the learning process and a more ethical use of the technologies available [28]. Calderón-Garrido, Carrera [29] Digital response systems were used in English lessons to practise vocabulary and grammar or as lesson warm - ups [24]. *Google, Kahoot, Duolingo and Quizziz* became the favourite tools of English PST during the pandemic to dynamize learning and although many were reluctant to include emerging technologies before, the pandemic changed their views [26]. However, they valued its use as an interactive complement not as a teacher substitute. These authors also found that when preservice teachers submitted their work through digital response systems, they were more willing to participate because of the anonymity implied.

Coannotation was a platform highly valued for video annotations by Martínez Romera and Robles [18] as a tool to share reflections among preservice teachers and their teacher educators since it allowed preservice teachers to read deeply and stop on specific fragments to comment. Wohlfart, Mödinger and Wagner [30] found tablets to be the favourite tools for physical education teachers for their possibilities of outdoors use. They also highlighted that when teacher educators used software to create content, preservice teachers increased their technical competence.

Within the group of articles dealing with ICT and emerging technologies, it is possible to observe subcategories depending on the tools included since some focused-on game-based learning or simulations whereas others presented different uses of augmented and/ or virtual reality and the studies closest to the present also depicted uses of artificial intelligence including GenAI. Calderón-Garrido et al. [29] recognized more inclusion of ICT and emerging technologies in virtual lessons. In general, we can see that new technologies are being used in initial teacher education and depending on the uses given, we can speak of more instrumental or more pedagogical uses. We believe that technology integration within the framework of active methodologies could increase preservice teachers' digital literacy.

V. CONCLUSION

This paper presents the preliminary findings from a systematic literature review on ICT, emerging technologies, and active methodologies in initial teacher education suggesting a significant gap. While the educational literature highlights the importance of integrating technology for pedagogical benefit, preservice teachers often lack the necessary preparation to utilize ICT and emerging technologies in a meaningful way. The limited number of research papers retrieved focusing on active methodologies indicates that when new technologies are incorporated, their use tends to be merely instrumental or in the framework of traditional educational practices.

In the studies we analysed, we identified the following active methodologies: collaborative learning, gamification, flipped classroom, project-based learning, problem-based learning, simulations, microteaching and STEM. According to researchers, their incorporation by teacher educators contributed positively to the development of technological, pedagogical and social skills of preservice teachers but if we consider the small number of studies in which preservice teachers were asked to integrate ICT and emerging technologies using active methodologies, it is possible to assume that teacher educators also need training in these approaches to be able to give preservice teachers the tools and the preparation they need to include these ICT- supported active pedagogies in their future classrooms.

The active methodologies used proved to foster motivation, creativity, collaboration, problem-solving and critical thinking which are all necessary skills for 21st century future teachers and students. In agreement with researchers, we conclude that the importance of using ICT and emerging technologies within the context of active methodologies lies in the fact that when new technologies are not included in a reflective way, they can reproduce old teaching models and although they may bring fun to the classroom, they may be far from transforming educational practices.

Overall, the results of this systematic review emphasize the need to prepare preservice teachers for integrating ICT and emerging technologies along with active pedagogies.to enhance the quality of education in an increasingly digital world.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

SCS conducted this systematic literature review, analysed the data and wrote the paper. RBA supervised the research done and the final version of the paper.

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